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ON SPECTROSCOPIC BINARIES AND THE DETERMINATION OF PARALLAX

BY W. H. WRIGHT

The binary character of many stars, as revealed by the spectro-scope, stands in a relation to the problem of determining their "trigonometrical parallaxes" that can hardly have escaped the attention of many astronomers. In those instances in which the resolution of the star has also been accomplished by means of the telescope, application has been made of the data furnished by that instrument and the spectroscope to the determination of the absolute parallax of the star, but the bearing of the duplicity of a system in which one member only is effectively bright, on measures undertaken to determine its parallax, seems not to have received extended consideration in published writings. The following remarks deal primarily with systems of that character, and in order to avoid continual qualification of the term, the expression *spectroscopic binary* will, in this note, be used to designate a double system in which the light comes, in effect, from only one of the members.

The incidence of the matter of "spectroscopic" duplicity, of the kind referred to, on the problem of measuring parallax, results from the fact that a limited tho not inconsiderable number of orbits are comparable in size with that of the Earth, so that the apparent excursion of the star in the sky, even after allowance for its proper motion, is not wholly attributable to parallactic displacement, but includes its own orbital motion as well. If the observations extend over a considerable period of time the factors making for the elimination of the star's peculiar motion become increasingly effective, but in an investigation of the nature of that of parallax, where the result sought is of the order of the probable error of measurement, it is advisable to adopt every possible precaution, particularly when, as is the case in the matter under discussion, by so doing we may exact from the data of observation information hardly secondary in importance to a knowledge of the parallax itself.

It is in general impossible to predict, from a knowledge of the "spectroscopic" orbit alone, the magnitude of the extra-parallactic disturbance to be expected, even when the parallax is known; for the orbital radius is not determinate, being involved in the product $a \sin i$, which is the quantity yielded by the spectroscopic obser-

vations. The least possible value of the radius¹, corresponding to $i=90^\circ$, is, however, represented by this product, and even under the unfavorable assumption that such is the value of the inclination there are a number of systems comparable in size with that of the Earth-Sun. Table 1 records those orbits of Aitken's general list² which have values of $a \sin i$ in excess of 0.4 of the radius of the Earth's orbit³. In column 3 the value of this quantity is expressed in millions of kilometers. The radius of the Earth's orbit in the same terms is about 150. Since the mean value of the factor (taken for a large number of binaries having orbital planes inclined at random) by which this product must be multiplied to give the actual radius, is $\frac{\pi}{2}$, or about 1.6, and since there are undoubtedly particular cases in which this value is exceeded, it is quite probable that some of the orbits of the list are very large, and that others not included, thru showing too small a value of $a \sin i$, may also be of considerable dimensions.

Where the periods are long, as in the cases of α *Phoenicis* and a number of other stars, it is in general fair to assume that the orbital motion will pass as part of the proper motion of the star, provided the observations do not extend thru too long an interval. In this connection it may be noted that three of the stars of Table 1, *i. e.*, χ *Draconis*, β_1 *Capricorni* and η *Pegasi*, are included in the recently published list of parallaxes determined at the Leander McCormick Observatory, and all show exceptionally large discrepancies in proper motion, as determined respectively by parallax, and by meridian circle observations. For the second and third of these stars the value of the parallax is possibly not affected, but as the period of χ *Draconis* is only $3/4$ of a year it is not unlikely that the effect of the orbital motion of the star was felt in the measures. If the parallax observations are all made at the same phase of the stellar orbit the effect of the star's peculiar motion will not enter, and it would appear advisable, in instances where disturbance may be anticipated, to arrange to have the observations fall at the appropriate times, if such a disposition should, in other respects, prove practicable.

¹For simplicity the term radius will be used in this note to designate the semi-major axis.

²*The Binary Stars*, 296. A few orbits not given by Aitken have been added.

³The contents of the table have not been critically scrutinized. It has been attempted to exclude unsuitable subjects, such as orbits of doubtful dependability, and systems in which both components are bright, but anyone desiring data to be used in conjunction with observations for parallax should consult original sources of information. Two of the stars, ν *Sagittarii* and β_1 *Capricorni*, have composite spectra, and the fainter components may therefore be not entirely negligible.

The subject just discussed is intimately related to another which has interesting possibilities, namely, the determination of the "telescopic" orbit of the spectroscopic binary. When we recall that for two stars, *Sirius* and *Procyon*, this has actually been done with the meridian circle, it would seem not improbable that, with the increased accuracy afforded by differential measurements from close comparison stars, other systems might yield to this method of investigation. It must be admitted at once that with *Sirius* and *Procyon* the conditions are particularly favorable for observations of this kind, both on account of the nearness to us of the stars, and the magnitude of the orbits, and one might be disposed to doubt whether, even with the added accuracy of a more suitable means of observation, the method would find an application to spectroscopic binaries in general. On the other hand it may be said that the effect is in instances greater than the parallax, that it should be eliminated from the latter, and that it would therefore seem particularly appropriate to take on the necessary observations as an adjunct to those made for parallax, since both are precisely of the same kind. With the admittedly inexact "telescopic" orbit which the observations would furnish it would probably be possible, in some instances at least, to separate the two factors of $a \sin i$, and thus establish the dimensions of the star's orbit as well as an independent value of the absolute parallax.

Observations for the purpose just indicated should be made at the same season in successive years, the necessary exactness of date being dependent upon a number of circumstances, among others, the period and latitude of the star. It is quite probable that, where the regular parallax observations of a binary of the kind we are considering have extended over many years, the two groups of observations corresponding to opposite parallactic elongations might serve for independent solutions. Academically speaking, the problem is of course susceptible to simultaneous solution for the parallax and the dimensions of the orbit, but in view of the relatively large errors of observation it seems probable that particular methods of attack, adapted to one case or another, will be found more satisfactory.

With respect to the stars mentioned as being included in the parallax list of the Leander McCormick Observatory, the continuation of their observation would be of interest. For χ *Draconis*, even with the unfavorable position of the line of apsides, the

double displacement to be measured would be at least $0''.06$, and probably considerably larger. The parallaxes of η Pegasi and β_1 Capricorni are evidently indeterminate by the direct method, since the value for the first is negative, and for the second, extremely small. The orbital displacements of the stars are, respectively, at least equal to, and two and a half times their parallaxes, and are possibly greatly in excess of these amounts, so that it may eventually be possible to solve for the parallaxes in terms of their own orbital base lines, rather than that of the Earth.

These considerations have been in mind for many years, and I should be disposed to regard them as generally recognized, were it not for the fact that I have, in general reading, encountered no explicit reference to them. While this statement should be supplemented by a confession of the casualness of my acquaintance with the branch of astronomy devoted to the measurement of stellar distances, it may be said on the other hand that a number of excellent reviews of the present status of the parallax problem, which have recently become available, do not mention the possibility of disturbances such as those here considered. The subject is incidentally referred to in a note of my own dealing with the absolute parallax of α Centauri⁴, but in view of the growing interest in parallax determinations, it has seemed worth while, at the risk of repeating a good deal that is generally understood, to develop it somewhat further.

TABLE I
 $a \sin i$
(million km.)

Star	α	$a \sin i$ (million km.)	Period
α Phoenicis	$0^h 21^m$	308	$10^y.6$
π Andromedae	31	77	143^d
β Persei	3 2	89	$1^y.9$
μ Persei	4 8	80	284^d
χ Aurigae	5 26	182	$1^y.8$
α Orionis	50	70	6^y
γ Geminorum	6 32	175	$6^y.0$
σ Puppis	7 26	64	258^d
κ Velorum	9 19	73	117^d
ϵ Urs. Majoris	12 50	69	$4^y.2$ Mg-line found for second comp., on 2 plates
β Herculis	16 26	60	$411^d = 1^y.13$
μ Sagittarii	18 8	144	180^d
χ Draconis	23	62	282^d
ν Sagittarii	19 16	91	138^d
α^2 Cygni#	20 12	263	$3^y.21$
β_1 Capricorni	15	377	$1375^d = 3^y.76$
η Pegasi	22 38	158	$2^y.24$

⁴Lick Obs. Bull., 3, 5, 1904.

#There is some chance for confusion to result from the designation of this star. It is H. R. 7751 = D. M. + $47^\circ 30'50$, and is designated α^2 in the revised Harvard Photometry. The star referred to as α^2 Cygni in the Leander McCormick parallax list is another object: H. R. 7735 = D. M. + $46^\circ 28'52$.